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Demographic Correlates of Movement Behaviors in Infants: A Longitudinal Study

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Background: Demographic correlates of movement behaviors in infants are unclear. This study examined the longitudinal associations between demographic correlates and movement behaviors in infants. **Methods**: Participants were 411 parents of infants from the Early Movers project in Edmonton, Canada. Movement behaviors, infant and parental age, and nonparental care time were assessed using a parental questionnaire at 2, 4, and 6 months of age. Other infant and parental demographic variables were assessed at 2 months of age. Linear and generalized linear mixed models were conducted. **Results**: Infant age was associated with all movement behaviors except for restrained time. White infants and those with older parents had less tummy time but increased odds of having reading time. Infants of the most educated parents also had lower tummy time. Higher parental education and more siblings were associated with no screen time and longer infant sleep time. Infants with immigrant parent(s) were less likely to have reading time. No associations were found for infant sex, time spent in nonparental care, and parental marital status. **Conclusion**: Since no single demographic group demonstrated healthy patterns for all movement behaviors, promotion of a healthy balance of movement behaviors may be needed universally for all infants.

Keywords: infancy, determinant, sedentary behavior, sleep, early chlidhood

Movement behaviors (ie, physical activity, sedentary behavior, sleep) are crucial for healthy development in young children as early as infancy (<1 y). For instance, tummy time (or time awake in the prone position), a form of physical activity for infants who are not yet mobile, has been associated with gross motor development, lower adiposity, and prevention of brachycephaly.[1] By contrast, prolonged screen time (eg, poor inhibition control[2]) and short sleep duration (eg, increased internalizing problems[3]) in infants appears to be associated with unfavorable developmental outcomes later in life. Consequently, international and national 24-hour movement guidelines recommend a healthy balance of movement behavior for infants.[4–6] However, there is some evidence to suggest that most infants do not meet these guidelines. For instance, in a surveillance study of 455 infants from Australia (mean age of approximately 4 mo), only 4% met the overall guidelines.[7] Therefore, it important to promote healthy movement behaviors in infants. Identifying key demographic correlates of movement behaviors can help determine at-risk populations for the purpose of developing targeted intervention strategies.

Most studies included in previous systematic reviews on demographic correlates of movement behaviors have focused on toddler (1–2 y) and preschool (3–4 or 3–5 y) aged children; research in infants is lacking.[8–13] This gap is salient because evidence in toddlers and preschoolers may not be generalizable to infants due to their distinct movement behavior patterns. For example, tummy time is a common form of physical activity for infants who are not yet mobile but is not relevant to ambulatory toddlers and preschoolers.[1] In addition, consolidation of sleep occurs during infancy.[14] By contrast, toddlers and preschoolers are typically more ambulatory than infants[15] and have more consolidated sleep.[14] Therefore, examination of the demographic correlates of movement behaviors exclusively in infants is needed.

The minimal evidence that does exist on the demographic correlates of movement behaviors in infants has some limitations. For example, findings are primarily based on cross-sectional data.[8,11] In addition, evidence on screen time is limited by the common focus on television viewing and the lack of consideration for contemporary devices, such as cell phones and tablets.[10] Moreover, demographic correlates of different types of sedentary behaviors, such as restrained time and reading time, have been particularly understudied.[7,16] Therefore, the objective of this study was to examine the longitudinal associations between demographic variables and movement behaviors (ie, tummy time, restrained time, reading time, screen time, sleep time) in a sample of infants.

Methods

Study Design and Participants

Participants were parents and their infants from the Early Movers project, which employed a longitudinal study design. In partnership with Alberta Health Services, families were recruited at routine 2-month immunization appointments at 1 of 5 large public health centers in Edmonton, Canada that served diverse communities. To be eligible, infants needed to be aged 2 months (ie, between 2 mo 0 d and 2 mo 30 d) at baseline. Participants were not eligible if parents/guardians did not confidently speak or read English, and/or if infants (1) were regularly cared for by an adult other than their parent/guardian for a number of hours per week (eg, attended full-time childcare), (2) born preterm (gestational age <37 wk) or underweight (<2500 g), and/or (3) had a medical condition or health complication since birth that could have an impact on infant movement behaviors or development. Of the 808 families approached from March 2018 to November 2019, 178 were deemed ineligible. Of the 630 eligible families, 423 (77.4%) agreed to participate. Specific to this study, participating parents completed a

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questionnaire at the 2-month immunization appointment and a similar questionnaire at home when their infants were aged 4 and 6 months. The 4- and 6-month questionnaires included age-specific development questions and excluded some demographic questions that were not expected to change from the 2-month questionnaire.

Ethics approval was obtained from the University of Alberta Research Ethics Board. Written informed consent was obtained from all participating parents/guardians.

Measures

The following infant demographic variables were collected in the 2-month baseline questionnaire: date of birth; sex (male or female); race/ethnicity (Aboriginal, white, South Asian, Chinese, African, Filipino, Latin American, Arab, Southeast Asian, West Asian, Korean, Japanese, or other race); and the number of younger and older siblings. At all 3 time points, parents reported any *nonparental care time* based on the number of hours per week their infants spent in with individuals other than their parents. *Infant age* (in days) was calculated using the reported infant's birth date and the date of data collection at each time point. *Infant sex* was categorized as male or female. *Infant race/ethnicity* was dichotomized into white or other races/ethnicities based on the frequency distribution. *The number of sibling(s)* was recoded as 0, 1, and 2 or more siblings.

The following parent characteristics were collected in the 2-month parental questionnaire: date of birth; marital status (married, living common-law, widowed, separated or divorced, or single or never married); education level (less than high school diploma, high school diploma, college or trade certificate or diploma, bachelor's degree, or university certificate, diploma or degree above the bachelor's level); and whether they were born in Canada (yes or no). *Parent age* (in years) was calculated using the reported parental birth date and the date of data collection at each time point. Based on the frequency distributions, response options for *parental marital status* were dichotomized as married or living common law, and not married; response options for *parental education* were categorized as below bachelor level, bachelor's degree, and above bachelor level. *Parental country of birth* was categorized as Canada or other countries.

Infant movement behaviors were assessed in the child's daily activities section of the parental questionnaire at all 3 time points. At the beginning of this section, detailed instructions and examples were provided on how to record the duration of various daily activities. Parents reported the average wake time per day that their infant spent in tummy time where the infant was free to move. Responses in hours and minutes were used to calculate *tummy time* in minutes per day. Parents also reported the average daily wake time their infant spent in restrained activities, including (1) a stroller, (2) a car seat, (3) a baby carrier, sling, or wrap, (4) an indoor swing, and (5) a high chair or other chair with safety straps. Responses (in hours and minutes) were converted to minutes per day for each these activities, and summed for *restrained time*. In addition, parents reported the average hours and minutes that infants spent reading/looking at books with the parents or other children/adults, and response (in hours and minutes) were used to calculate *reading time* (in minutes per day). Screen time was assessed using 2 separate questions in which parents reported the average time per day that their child spent watching/looking at a (1) television and (2) cell phone or tablet. Responses (in hours and minutes) were used to calculate minutes per day that the infant spent in each type of screen use, which were summed for *screen time*. Parents also reported the total average time that the infant slept per night (adding up time between night feedings) and throughout nap time during the day (adding up time spent in all naps). Responses (in hours and minutes) were used to calculate minutes per day that the infant spent in nighttime sleep and daytime sleep (ie, naps), which were summed for *sleep time*. The questions regarding infant tummy time, restrained time, and screen time were adapted from a previous study, where 2-week test–retest reliability was observed for infants (intracorrelation coefficients range .20–.86).[17] The questions regarding infant sleep time were adapted from another previous study where 1-week test–retest reliability was observed (intracorrelation coefficients = .78, unpublished data) in young children.[18] In addition, concurrent validity for the tummy time question has been previously examined in a subsample of participants from the Early Movers project, and a large effect size was observed for the correlations between the questionnaire measure of tummy time and a validated accelerometer measure of tummy time at 6 months of age ($r_s = .60$).[19,20] Finally, significant correlations with medium to large effect sizes ($r_s = .30$–$.56$) were observed between the questionnaire measure and a 3-day time use diary measure of these movement behaviors across time points in a subsample of participants from the Early Movers project.[20,21] A more detailed description of the diary measures could be found elsewhere.[19]

Statistical Analyses

All statistical analyses were performed using SPSS (version 26.0; SPSS Inc, Chicago, IL). Dependent variables (tummy time, restrained time, reading time, screen time, and sleep time) were checked for normality and outliers. Impossible observations (eg, 35 h of total sleep) for each movement behavior were removed (tummy time, n = 4; restrained time, n = 2; total screen time, n = 2; total sleep time, n = 6). Data for tummy time and restrained time were square-root transformed to meet assumptions of normality. Data for reading time and screen time were also not normally distributed, though square-root transformation did not improve the distribution. Therefore, data for reading time (code "0": no reading time; code "1": having reading time) and screen time (code "0": no screen time; code "1": having screen time) were dichotomized based on frequency distributions. Mean imputation was performed for 5 participants who were missing parental age.

Descriptive statistics were calculated for demographic variables at each time point, and descriptive characteristics of movement behaviors can be found elsewhere.[21] Infant age was centered around 60 days for all time points, and growth curve modeling were conducted to examine the longitudinal associations between demographic variables and movement behaviors in infants. Specifically, linear mixed models were performed to examine the associations between demographic variables and continuous dependent variables (square-root transformed tummy time, square-root transformed restrained time, and total sleep time), and generalized linear mixed models were performed to examine the associations between demographic variables and categorical dependent variables (reading time and total screen time). Participants who had at least one observation for any movement behavior were included in the analyses. In the models with time varying demographic correlates, the unstandardized beta coefficients can be interpreted as the pooled within- and between-individual difference in the movement behaviors across the 3 time points, and the odds ratio (OR) can be interpreted as the pooled within- and between-individual odds of participating in the

movement behavior (vs not participating in the behavior) across the 3 time points. In models with baseline demographic variables, the unstandardized beta coefficients can be interpreted as between-demographic group differences in the mean of the movement behavior variable across the 3 time points. The OR can be interpreted as the odds of participating in the behavior (vs not participating in the behavior) across the 3 time points in a demographic group compared with the reference group.

To identify the model of best fit, a modeling building strategy was employed. The first model included a random intercept, and subsequent models gradually got more complex, considering a fixed linear slope of infant age, a fixed quadratic slope of infant age, and/or a random linear slope of infant age. Model comparisons were conducted using the likelihood ratio test, and a significant test indicates improvement in model fit. In addition, Akaike Information Criterion (for linear mixed models) and Bayesian Information Criterion (for generalized linear mixed models) were considered for model comparison (smaller values represent better fitting models). Once the best model fit for each movement behavior variable was identified, each demographic variable was respectively included in the model (simple regression model). Demographic variables that met a cutoff of $P < .10$ in the simple regression models for a movement behavior variable were then all included in a multiple regression model for that movement behavior variable.[22,23] Statistical significance was set at $P < .05$.

Results

Of the 423 families that agreed to participate in the project, 4 had infants diagnosed with a medical condition or developmental delay during the project, 7 withdrew, and one had no valid observations for movement behaviors at any time point. Therefore, data from the remaining 411 participants were included in the analyses. Descriptive information on demographic variables and movement behaviors are presented in Table 1.

The simple regression models for the longitudinal associations between demographic variables and movement behaviors are displayed in Table 2. In models for square-root transformed tummy time, the associations for infant age (squared), infant race/ethnicity, parental age, parental marital status, and parental education met the $P < .10$ cutoff. In models for square-root transformed restrained time, the associations for the number of siblings, parental age, parental marital status, and parental education met the $P < .10$ cutoff. In models for reading time, infant age, infant race/ethnicity, number of siblings, parental age, parental education, and parental country of birth met the $P < .10$ cutoff. In models for screen time, infant age, number of siblings, parental age, parental marital status, and parental education met the $P < .10$ cutoff. Finally, in models for sleep time, infant age, number of siblings, parental marital status, and parental education also met the $P < .10$ cutoff. Infant sex and nonparental care time were not associated with any movement behaviors.

Table 1 Infant and Parental Demographic Characteristics (n = 411)

	2 mo	4 mo	6 mo
Infant age, d	66.88 (0.30)	128.01 (0.48)	186.93 (0.45)
Infant sex			
Male	180 (43.8)	—	—
Female	234 (56.2)	—	—
Infant race/ethnicity			
White	203 (49.4)	—	—
Other	208 (50.6)	—	—
Number of siblings			
0	190 (46.2)	—	—
1	157 (38.2)	—	—
2 or more	64 (15.6)		
Nonparental care time, h	2.26 (0.59)	2.59 (0.42)	2.61 (0.38)
Parental age, y[a,b]	31.78 (0.26)	31.78 (0.26)	31.93 (0.25)
Parental marital status			
Married or living common law	388 (94.4)	—	—
Not married	23 (5.6)	—	—
Parental education			
Above bachelor's degree	83 (20.2)	—	—
Bachelor's degree	142 (34.5)	—	—
Below bachelor's degree	186 (45.3)	—	—
Parental country of birth			
Canada	283 (68.9)	—	—
Other countries	128 (31.1)	—	—

Note: Values are presented as mean (SE) for normally distributed continuous variables (infant age, parental age, and nonparental care time) and frequencies (percentages) for categorical variables (infant sex and race/ethnicity, number of siblings, nonparental care time, parental marital status, education, and country of birth).
[a]Mean imputation was performed for missing data at baseline (n = 5). [b]Due to decimal rounding, parental age at 2 months (mean = 31.781, SE = 0.262) and at 4 months (mean = 31.784, SE = 0.256) looks the same.

Table 2 Simple Regression Models for Longitudinal Associations Between Demographic Variables and Movement Behaviors in Infants (n = 411)

	SQR (tummy time)[a]		SQR (restrained time)[b]		Read time[b,1] (having vs no)		Screen time[b,2,3] (having vs no)		Sleep time, h/d[b,c]	
	B (95% CI)	*P* value	*B* (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value	*B* (95% CI)	*P* value
Infant age, d										
	0.002 (–0.01 to 0.02)	.826	0.002 (–0.003 to 0.007)	.360	**1.02 (1.02 to 1.03)**	**<.001**	**1.01 (1.01 to 1.02)**	**<.001**	–0.002 (–0.005 to 0.0002)	.075†
Infant age (squared)										
	0.0002 (0.0001 to 0.0003)	**<.001**	—	—	—	—	—	—	—	—
Infant sex (reference group: female)										
Male	0.15 (–0.45 to 0.75)	.623	–0.09 (–0.80 to 0.62)	.805	0.80 (0.53 to 1.20)	.279	0.98 (0.67 to 1.44)	.914	0.22 (–0.20 to 0.65)	.303
Infant race/ethnicity (reference group: other races/ethnicities)										
White	–0.51 (–1.10 to 0.09)	.095†	–0.03 (–0.73 to 0.68)	.942	**4.20 (2.75 to 6.42)**	**<.001**	0.78 (0.53 to 1.14)	.193	0.29 (–0.13 to 0.71)	.171
Number of siblings (reference group: 0)										
1	–0.11 (–0.76 to 0.54)	.743	0.30 (–0.46 to 1.07)	.436	0.82 (0.53 to 1.29)	.398	**0.53 (0.35 to 0.80)**	**.003**	**0.92 (0.47 to 1.37)**	**<.001**
2 or more	0.50 (–0.38 to 1.37)	.267	0.92 (–0.12 to 1.95)	.083†	**0.50 (0.28 to 0.90)**	**.021**	**0.42 (0.24 to 0.73)**	**.002**	**0.81 (0.20 to 1.37)**	**.010**
Nonparental care time, h										
	0.01 (–0.01 to 0.03)	.438	0.01 (–0.02 to 0.04)	.620	0.99 (0.97 to 1.01)	.310	1.00 (0.99 to 1.02)	.700	–0.01 (–0.03 to 0.006)	.204
Parental age, y[d]										
	–0.15 (–0.20 to –0.09)	**<.001**	**–0.08 (–0.14 to –0.01)**	**.028**	1.04 (1.00 to 1.08)	.082†	**0.95 (0.91 to 0.98)**	**.004**	0.02 (–0.02 to 0.06)	.431
Parental marital status (reference group: not married)										
Married or living common law	**–2.29 (–3.60 to –0.98)**	**.001**	**–1.67 (–3.27 to –0.06)**	**.042**	1.10 (0.44 to 2.77)	.839	**0.39 (0.16 to 0.96)**	**.039**	0.92 (–0.07 to 1.90)	.068†
Parental education (reference group: below bachelor's degree)										
Above bachelor's degree	**–1.89 (–2.66 to –1.12)**	**<.001**	**–1.04 (–1.96 to –0.13)**	**.026**	0.47 (0.55 to 1.60)	.814	**0.25 (0.15 to 0.41)**	**<.001**	**1.09 (0.55 to 1.64)**	**<.001**
Bachelor's degree	**–0.99 (–1.65 to –0.34)**	**.003**	**–1.54 (–2.32 to –0.75)**	**<.001**	**1.77 (1.10 to 2.84)**	**.019**	**0.39 (0.25 to 0.59)**	**<.001**	**0.91 (0.44 to 1.37)**	**<.001**
Parental country of birth (reference group: Canada)										
Other countries	0.09 (–0.56 to 0.73)	.794	–0.21 (–0.97 to 0.56)	.593	**0.23 (0.15 to 0.36)**	**<.001**	1.34 (0.89 to 2.02)	.168	–0.17 (–0.62 to 0.29)	.479

Abbreviations: CI, confidence interval; OR, odds ratio; SQR, square root transformed. Note: Bold indicates $P < .05$.

[a]Model fitting: random intercept + fixed linear slope + random linear slope + quadratic slope. [b]Model fitting: random intercept + fixed linear slope. [c]Participants with no valid data at all time points were excluded from the analyses (n = 4). [d]Mean imputation was performed for the missing data at baseline (n = 5).

[1]Data for reading time was dichotomized based on frequencies: code "0": no reading time (reference group); code "1": having reading time. [2]Data for screen time was dichotomized based on frequencies: code "0": no screen time (reference group); code "1": having screen time. [3]A similar association was observed for TV time, as well as cell phone and tablet time, respectively.

†$P < .10$.

The multiple regression models for the longitudinal associations between demographic variables and movement behaviors are shown in Table 3. A quadratic (convex) longitudinal association was found between infant age and tummy time (Figure 1). In addition, being white (vs other races/ethnicities; $B = -0.60$; 95% confidence interval [CI], −1.17 to −0.03), having a parent with an education above a bachelor's degree (vs below a bachelor's degree; $B = -1.40$; 95% CI, −2.19 to −0.61) as well as having an older parent ($B = -0.12$; 95% CI, −0.17 to −0.06) were associated with lower square-root transformed infant tummy time across the 3 time points.

For square-root transformed restrained time, having 2 or more siblings (vs zero sibling; $B = 1.24$; 95% CI, 0.20 to 2.28) was associated with higher square-root transformed restrained time across 3 time points. Though, the association for having one sibling group, compared with zero siblings, was not significant. By contrast, parent with a bachelor's degree (vs below a bachelor's degree; $B = -1.33$; 95% CI, −2.14 to −0.52) was associated with lower square-root transformed restrained time across 3 time points. However, no significant differences in square-root transformed restrained time were observed between parental education above a bachelor's degree and below a bachelor's degree.

For reading time, older infant age (OR = 1.02; 95% CI, 1.02 to 1.03), being white (vs other races/ethnicities; OR = 2.62; 95% CI, 1.61 to 4.23), and having an older parent (OR = 1.05; 95% CI, 1.00 to 1.09), were associated with higher odds of having reading time across the 3 time points. However, infants whose parents were born outside of Canada were less likely to have reading time across the 3 time points compared with those whose parents were born in Canada (OR = 0.34; 95% CI, 0.21 to 0.56).

For screen time, older infant age (OR = 1.01; 95% CI, 1.01 to 1.02) was significantly associated with higher odds of having screen time across the 3 time points. However, infants having one (OR = 0.53; 95% CI, 0.35 to 0.80) or 2 or more siblings (OR = 0.40; 95% CI, 0.22 to 0.71) were less likely to have screen time, compared with infants with no siblings. In addition, infants whose parental education level was a bachelor's degree (OR = 0.41; 95% CI, 0.26 to 0.64) or above (OR = 0.25; 95% CI, 0.14 to 0.42) were less likely to have screen time across the 3 time points, compared with those whose parental education level was below a bachelor's degree.

For sleep time, a negative association was observed for infant age ($B = -0.002$; 95% CI, 0.01 to −0.00004). Though, infants having one ($B = 0.92$; 95% CI, 0.48 to 1.36) or more siblings ($B = 0.79$; 95% CI, 0.19 to 1.39) had more total sleep across the 3 time points than those with no siblings. In addition, infants whose parental education level was a bachelor's degree ($B = 0.84$; 95% CI, 0.37 to 1.31) or above ($B = 1.07$; 95% CI, 0.52 to 1.61) had longer sleep time across the 3 time points than those whose parental education level was below a bachelor's degree.

Discussion

This study aimed to identify longitudinal demographic correlates of tummy time, restrained time, reading time, screen time, and sleep time in infants. The growth curve analysis demonstrated significant changes in most infant movement behaviors over a relatively short period of time. Overall, no demographic correlate was associated with optimal longitudinal movement behavior patterns of higher tummy time, sleep time, and reading time as well as lower screen time and restrained time. For instance, white infants and those with an older parent were more likely to have reading time but had lower tummy time. In addition, infants with parents who were more highly educated had longer total sleep time and were more likely to have no screen time but also had lower tummy time. Likewise, infants having more siblings had longer total sleep time and were less likely to have screen time but had more restrained time. Minimal evidence was observed for the associations between some demographic correlates and longitudinal movement behaviors. Specifically, parental country of birth was only associated with reading time. Infant sex and nonparental care time were not associated with any movement behaviors in simple regression models. Finally, parental marital status was not associated with any movement behaviors in multiple regression models.

The quadratic (convex) relationship between infant age and tummy time observed in our study indicates that tummy time may increase at an accelerated rate across the first 6 months of an infant's life. This finding aligns with a recent systematic review examining the correlates of tummy time in infants, that found a consistent positive association between infant age and tummy time across 6 out of 9 studies.[8] These findings may suggest that infant tolerance and enjoyment of tummy time may increase with age.[24] Therefore, it may be helpful for health professionals to encourage caregivers to persist with tummy time as their infant gets older, even if initially they get upset after short bouts. Similar to our finding for parental age, the aforementioned systematic review also reported a negative association between parental age and tummy time and/or prone positioning ability in infants,[8] based on the cross-sectional finding of one Canadian study among 71 infants at 4 months of age.[25] However, given the limited number of relevant studies, our finding for the association between parental age and tummy time may need to be confirmed in future studies.

The associations observed in our study between infant race/ethnicity, parental education level, and tummy time were inconsistent with findings from other studies. For example, an American cross-sectional study with a sample of 817 parent–infant dyads found that compared with non-Hispanic white infants, Hispanic infants had less tummy time at 2 months of age,[26] whereas our study found white infants had less tummy time than those of other race/ethnicities. Though no previous study has examined the association between parental education and tummy time per se, a Dutch cohort study found that mothers with lower education levels were more likely to delay first time tummy time practice (ie, ≥3 wk).[27] Given the limited evidence, the associations between these 2 demographic variables and tummy time in infants need to be confirmed in future research. Nevertheless, our findings suggest that infants from white families and those with an older parent are more likely to engage in reading activities than their counterparts. Higher parental education also appeared associated with a healthier pattern of sedentary behavior (ie, less restrained time, less likely to engage in screen time) and longer sleep time in infants. Therefore, it is possible that these families and parents tend to prioritize practices to encourage healthy sedentary behavior patterns and/or sleep habits that may favor development in infants[28,29] but experience barriers to tummy time practices (eg, infant negative affect, anxiety about potential minor injuries).[24] However, this assumption needs to be confirmed in future research examining preference, facilitators, and barriers of parenting practices related to movement behaviors in infant age group.

In our study, several demographic correlates had different associations with different types of sedentary behaviors in infants. These findings in infants may provide an explanation for the null or indeterminate findings regarding the associations between demographic correlates and total sedentary time from a recent systematic

Table 3 Multiple Regression Models for Longitudinal Associations Between Demographic Variables and Movement Behaviors in Infants (n = 411)

	SQR (tummy time)[a]		SQR (restrained time)[b]		Reading time[b,1] (having vs no)		Screen time[b,2,3] (having vs no)		Sleep time, h/d[b,c]	
	B (95% CI)	*P* value	*B* (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value	*B* (95% CI)	*P* value
Infant age, d										
	0.004 (–0.01 to 0.02)	.561	0.003 (–0.001 to 0.01)	.179	**1.02 (1.02 to 1.03)**	**<.001**	**1.01 (1.01 to 1.02)**	**<.001**	**–0.002 (0.005 to 0.00004)**	**.046**
Infant age (squared)										
	0.0002 (0.0001 to 0.0003)	**<.001**	—	—	—	—	—	—	—	—
Infant sex (reference group: female)										
Male	—	—	—	—	—	—	—	—	—	—
Infant race/ethnicity (reference group: other races/ethnicities)										
White	**–0.60 (–1.17 to –0.03)**	**.038**	—	—	**2.62 (1.61 to 4.23)**	**<.001**	—	—	—	—
Number of siblings (reference group: 0)										
1	—	—	0.42 (–0.34 to 1.19)	.274	0.66 (0.41 to 1.06)	.083	**0.53 (0.35 to 0.80)**	**.003**	**0.92 (0.48 to 1.36)**	**<.001**
2 or more	—	—	**1.24 (0.20 to 2.28)**	**.020**	0.54 (0.29 to 1.01)	.052	**0.40 (0.22 to 0.71)**	**.002**	**0.79 (0.19 to 1.39)**	**.010**
Nonparental care time, h										
	—	—	—	—	—	—	—	—	—	—
Parental age, y[d]										
	–0.12 (–0.17 to –0.06)	**<.001**	–0.07 (–0.14 to –0.01)	.071	**1.05 (1.00 to 1.09)**	**.030**	0.99 (0.95 to 1.03)	.488	—	—
Parental marital status (reference group: not married)										
Married or living common-law	–1.27 (–2.59 to 0.05)	.059	–0.83 (–2.48 to 0.82)	.322	—	—	0.80 (0.32 to 2.00)	.797	0.35 (–0.63 to 1.33)	.480
Parental education (reference group: below bachelor's degree)										
Above bachelor's degree	**–1.40 (–2.19 to –0.61)**	**.001**	–0.64 (–1.59 to 0.32)	.194	1.05 (0.59 to 1.87)	.867	**0.25 (0.14 to 0.42)**	**<.001**	**1.07 (0.52 to 1.61)**	**<.001**
Bachelor's degree	–0.56 (–1.23 to 0.11)	.099	**–1.33 (–2.14 to –0.52)**	**.001**	1.63 (0.99 to 2.68)	.053	**0.41 (0.26 to 0.64)**	**<.001**	**0.84 (0.37 to 1.31)**	**<.001**
Parental country of birth (reference group: Canada)										
Other countries	—	—	—	—	**0.34 (0.21 to 0.56)**	**<.001**	—	—	—	—

Abbreviations: CI, confidence interval; OR, odds ratio; SQR, square-root transformed. Note: Bold indicates $P < .05$.

[a]Model fitting: random intercept + fixed linear slope + random linear slope + quadratic slope. [b]Model fitting: random intercept + fixed linear slope. [c]Participants with no valid data at all time points were excluded from the analyses (n = 4). [d]Mean imputation was performed for the missing data at baseline (n = 5).

[1]Data for reading time was dichotomized based on frequencies: code "0": no reading time (reference group); code "1": having reading time. [2]Data for screen time was dichotomized based on frequencies: code "0": no screen time (reference group); code "1": having screen time. [3]A similar association was observed for TV time, as well as cell phone and tablet time, respectively.

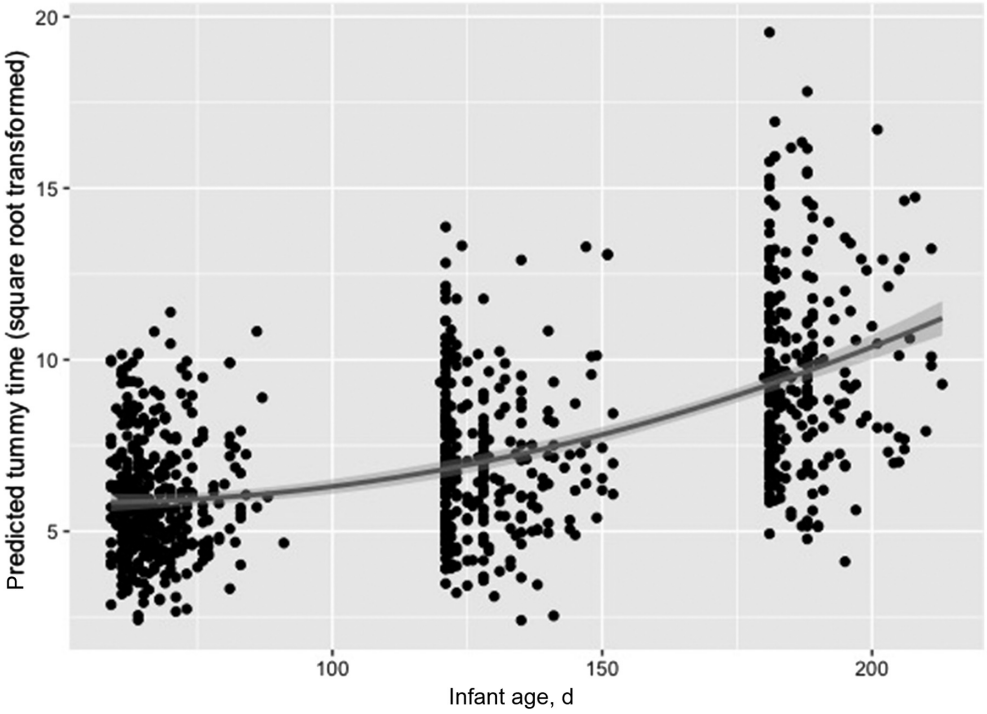

Figure 1 — Predicted change in tummy time (squared root transformed) with infant age (in days).

review focusing on toddlers and preschoolers aged 1–5.99 years.[12] The associations observed in our study in regard to restrained time and reading time are important additions to the current evidence base, as there is a scarcity of studies focusing on these movement behaviors and their correlates among infants.[7,16] In particular, our findings indicate that infants with 2 or more siblings may be at risk for prolonged restrained time. This is likely due to the fact that putting infants in a carrier, stroller, or swing can keep them safe while parents take care of other children in the household. Practical parenting practices that can minimize prolonged periods of restrained time in infants may need to be further explored and promoted in multichild families, especially in families with more than 2 children. Generally, there were fewer demographic correlates that were associated with restrained time compared with other movement behaviors in our sample. It could be that modifiable correlates are more important to restrained time in this age group, which needs to be confirmed in future research. As for reading time, in addition to infant race/ethnicity and parental age that have already been discussed, it appears that infant age and parent country of birth may also be relevant. For instance, infants who have an immigrant parent were at higher risk for no reading activities, compared with those from nonimmigrant families. Hypothetically, barriers to accessing books for immigrant parents may include lack of English proficiency, unfamiliarity with suitable English books for infant age group, and limited access to books in their native language.[30] More immigrant parents compared with nonimmigrant parents may also experience unique challenges, such as economic pressures, loss of extended family supports, and cultural adaptation,[31,32] that may limit their ability to provide reading opportunities for their infant (eg, unable to afford housing condition for a quite reading environment, no time for family reading activities).

The associations for most demographic variables that were examined in the current study with regard to screen time were mostly inconsistent with findings from systematic reviews examining correlates of screen time in the age range 0–8 years.[10,13,33] An exception was that these reviews have reported a consistent positive association between child age and screen time.[10,13,33] In line with this finding, our results also indicate the association may exist in infants as young as 2 months of age. Therefore, it appears important to promote healthy screen time habits in the earliest stage of life. Our findings also indicate that infants who have no siblings and whose parent has a lower educational level may be at higher risk for screen exposure and in most need of intervention. Similarly, a recent Australian study with a sample of 451 children found that those having no or fewer siblings were more likely to have more than 2 hours of screen time at the age of 18 months.[34] The explanation for this relationship between having no siblings and screen use in young infants is not clear and needs to be investigated in future research. Consistent with our findings for parental education, a recent longitudinal study found maternal education level was negatively associated with the amount of screen time in a sample of 1580 Danish infants.[35] As a potential explanation, findings from a Finnish cross-sectional study with a sample of 864 preschoolers, suggested a number of factors may mediate the associations between parental education and screen time in young children.[36] Specifically, this study illustrated that highly educated parents tended to have a lower limit for maximum screen time and place greater importance on limiting their child's screen time.[36] In addition, parents with a higher education level appeared to experience lower societal pressures to purchase screen devices and allow screen use for their child as well as spent less time using screen devices in front of children.[36] These mediating factors, in turn, were associated with less screen time in children.[36]

In terms of the demographic correlates of sleep time, the pattern of associations observed in our sample was the opposite of that associated with screen time. This finding may be explained by the fact that screen time tends to be inversely associated with total sleep time in young children.[11] In addition, our findings regarding infant age, parental education, and total sleep time appear consistent with evidence in young children. For example, previous studies examining normal sleep development in infants generally found a decreasing trend of total sleep duration with infant age.[14,37] Moreover, a recent longitudinal study with a sample of 206 Canadian toddlers and preschoolers also found a general trend of higher parental education with longer total sleep duration.[23] It appears that parental education is positively associated with parental knowledge regarding appropriate sleep practices and the importance of sleep for young children,[38,39] which in turn tends to facilitate better sleep outcomes for children in this age group.[40]

A main strength of this study was the focus on the infant age group, which fills an important gap in the literature. Additional strengths are the relatively large and diverse sample, the longitudinal design, and the inclusion of a wide range of movement behaviors, in particular different types of sedentary behaviors. The main limitation of our study is that parental-reported movement behaviors may be less accurate than objective measures.[19,41] Though the reliability of the reading time measure has not been examined, previous studies suggest that our measures of other movement behaviors are reliable.[17,18] In addition, the questionnaire measure and a time-used diary measure of all movement behaviors were significantly correlated across all time points in a subsample of participants, from the Early Movers project,[21] and, in particular, the tummy time measure has been found valid for use in studies examining associations with correlates in this age group.[19] Moreover, objective measures of some movement behaviors, such as reading time and screen time, that can be used in the field currently do not exist. Another limitation is that our study focused on the first 6 months of infancy only. However, the correlates of movement behaviors may not be the same for infants aged 7–11 months, which may need to be examined in future research. Though the correlates of tummy time would become less relevant in older infants as crawling and/or walking milestones are achieved.

Conclusion

Several demographic variables, including infant age and race/ethnicity, number of siblings, as well as parental age, education, and country of birth, appeared to be important correlates for movement behaviors in infants. These demographic correlates may need to be considered for adjustment in future research examining relevant movement behaviors and health indicators in this age group. In addition, since no single demographic group had healthy patterns for all movement behaviors in our sample, universal interventions may be needed to promote healthy balance of movement behaviors across all demographic groups. This finding also highlights the importance of pediatricians and other health professionals discussing the 24-hour movement guidelines with all families and providing strategic advice to improve guideline adherence in infants as part of routine well child visits.

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